Alpha Lake 2005-2012, 2021-2023
BC Lake Stewardship and Monitoring Program
Summary Report

BCLSS

BRITISH COLUMBIA

The BC Lake Stewardship Society (BCLSS) and the Ministry of Environment and Parks (ENV) partner with local volunteers and stewardship groups to characterize lake water quality through the *BC Lake Stewardship and Monitoring Program* (BCLSMP). The BCLSMP's focus is on understanding water clarity, temperature, oxygen, and nutrients because these factors contribute to the basic understanding of lake processes which influence biological productivity. Concerns about productivity are common, specifically because high productivity can negatively impact recreation, drinking water and aquatic health due to harmful algal blooms. For more information about the BCLSMP please visit www.gov.bc.ca/lakestewardshipmonitoring.

Photo 1. Photo of Alpha Lake by John Doyle

Background

Alpha Lake is located within the boundaries of the Resort Municipality of Whistler in the Coast Mountains of BC. The lake has a surface area of 15.18 ha, perimeter of 2.87 km and lies at an elevation of 632 m. The average depth of Alpha Lake is 4.3 m, and the deepest point is 11.6 m (BC Fish and Wildlife bathymetric map). Land use surrounding Alpha Lake consists of mixed residential and commercial development, and the watershed is approximately 68% forested. The CN railway borders the western edge of Alpha Lake, while Highway 99 is on a portion of the east side of Alpha Lake. At the north end of the lake is Alpha Lake Park which contains a dog park, two docks, and a raft, situated where Jordan Creek enters the lake. There is a house on an island in the middle of the lake and four large homes in the northeast corner. There are three multi-unit complexes on the lake, with Alpha Lake Village in the northeast corner (Doyle, 2024).

Epps & Phippen (2016) stated that none of the Whistler lakes are relied on for drinking water, irrigation, or industrial uses; instead, they are primarily used for primary and secondary contact recreation. There is one domestic water license issued to a home on Alpha Lake for 2.273 m3/day, however, the household is also connected to the municipal water system (Epps & Phippen, 2016). The Resort Municipality of Whistler collects weekly samples of beach water throughout the summer to test for fecal coliform to ensure the swimming area is safe for use (RMOW, 2024). Alpha Lake has been stocked annually with 500 triploid (sterile) rainbow trout since 2001 and stocked with diploid occasionally before 2001 (FFSBC, 2023).

During the development of the Whistler area, a significant portion of Alpha Lake was filled in, reducing the lake to roughly half of its original size and depth (Rebellato, 2005). Infill was used in 3 areas of the lake over the years: 1) at the southwest end in an area now called Condy Park, which was initially used for log storage and loading onto the railway 2) Alpha Lake Park at the north end had a green space and beach area that was expanded with fill, and 3) on the east side of the lake a land owner filled in a marshy area expanding their lot (Doyle, 2024). Due to the filling of the lake as well as the use of the lake for log storage, the lakebed now contains a considerable amount of sediment and organic debris (Rebellato, 2005). Due to the shallow depth of the lake, Alpha may be prone to re-suspension of bottom sediments, which BCLSS (2007) thought may lead to lower Secchi readings at times (reduced water clarity).

Nita Lake flows into Alpha Lake, via Jordan Creek, and the water then enters Millar Creek, eventually feeding into the Cheakamus River. Another significant tributary that flows into Alpha Lake is No Name Creek, which first runs through urban areas before entering the lake. Collins (2024) has noted that there is another basin downstream of Alpha Lake, known as the Tamarisk Basin. However, it is not known whether there is substantial water exchange between this downstream basin and Alpha Lake itself.

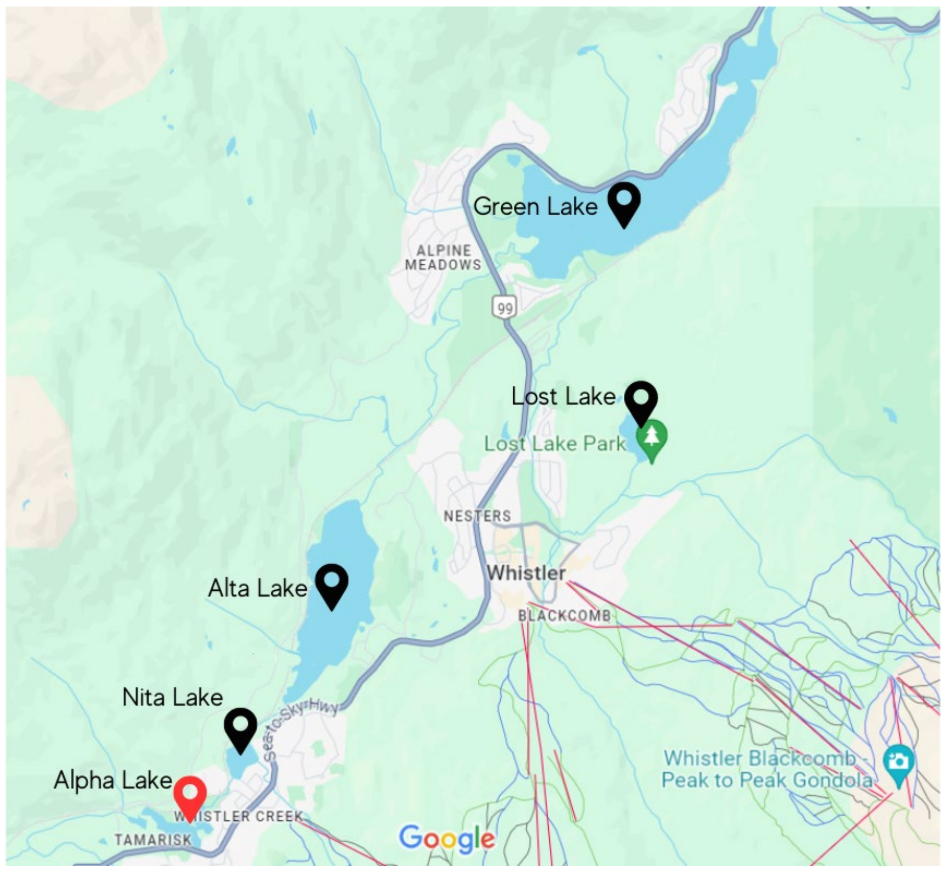


Figure 1. Google maps view of the location of Alpha Lake in relation to other Whistler Lakes

Reports have indicated that the hydrology in the area is mainly snowmelt-driven, with occasional fall water level peaks due to large rain events (Epps & Phippen, 2016). The British Columbia Ministry of Environment and Parks (ENV), in partnership with the Resort Municipality of Whistler (RMOW), have conducted water quality monitoring programs during stormwater events (October 2007) and snowmelt runoff periods (May 2008). This study by Bull (2009) found that chloride levels were elevated in Alpha Lake on May 6, 2008, during the snowmelt period. Bull (2009) believed these elevated levels to be due to snowmelt runoff received by No Name Creek and potentially from Alpha Lake's proximity to Hwy 99. Residents report that there are quite a number of stormwater conduits from streets and lots in Creekside near the southeastern side of Alpha Lake that enter the east edge of the lake (Collins, 2024).

The report by Bull (2009) offered recommendations to mitigate the impacts of storm and melt water on Whistler creeks. All recommendations pertaining to the Resort Municipality of Whistler (RMOW) have been acted on as part of the RMOW's environmental procedures and programs (Burhenne, 2024). "The RMOW continually monitors and manages stormwater to minimize impacts and to comply with legal regulations and BMP [best management practices]" (Burhenne, 2024). Some of the ways the RMOW addresses the impacts discussed by Bull (2009) include requiring all new developments to take stormwater impacts into account and working to limit road salt inputs into streams and lakes by requiring the roads team to submit road salt amounts regularly and by maintaining compliance with recommended levels (Burhenne, 2024).

Epps & Phippen (2016) began work on a *Water Quality Assessment and Objectives for Alta Lake, Alpha Lake, Lost Lake and Nita Lake: Resort Municipality Of Whistler, B.C.* However, this water quality assessment report was never finalized and is still in the draft stage. This draft report is referenced in various sections of this report. However, it is important to note that the sample site used for the 2016 ENV Water Quality Assessment (WQA) differed from the sample site used through the historic and current BCLSMP project. Please see **Figure 2** for a bathymetric map of Alpha Lake, which illustrates the location of both sample sites and the significant inflowing and outflowing streams.

The change in the sample site was made because the NE hole is relatively small and is surrounded by water shallow enough to isolate it from the deep waters elsewhere in the lake, and is also likely influenced by the inflowing Jordan Cr. The current site better represents Alpha Lake as a whole (Collins, 2024).

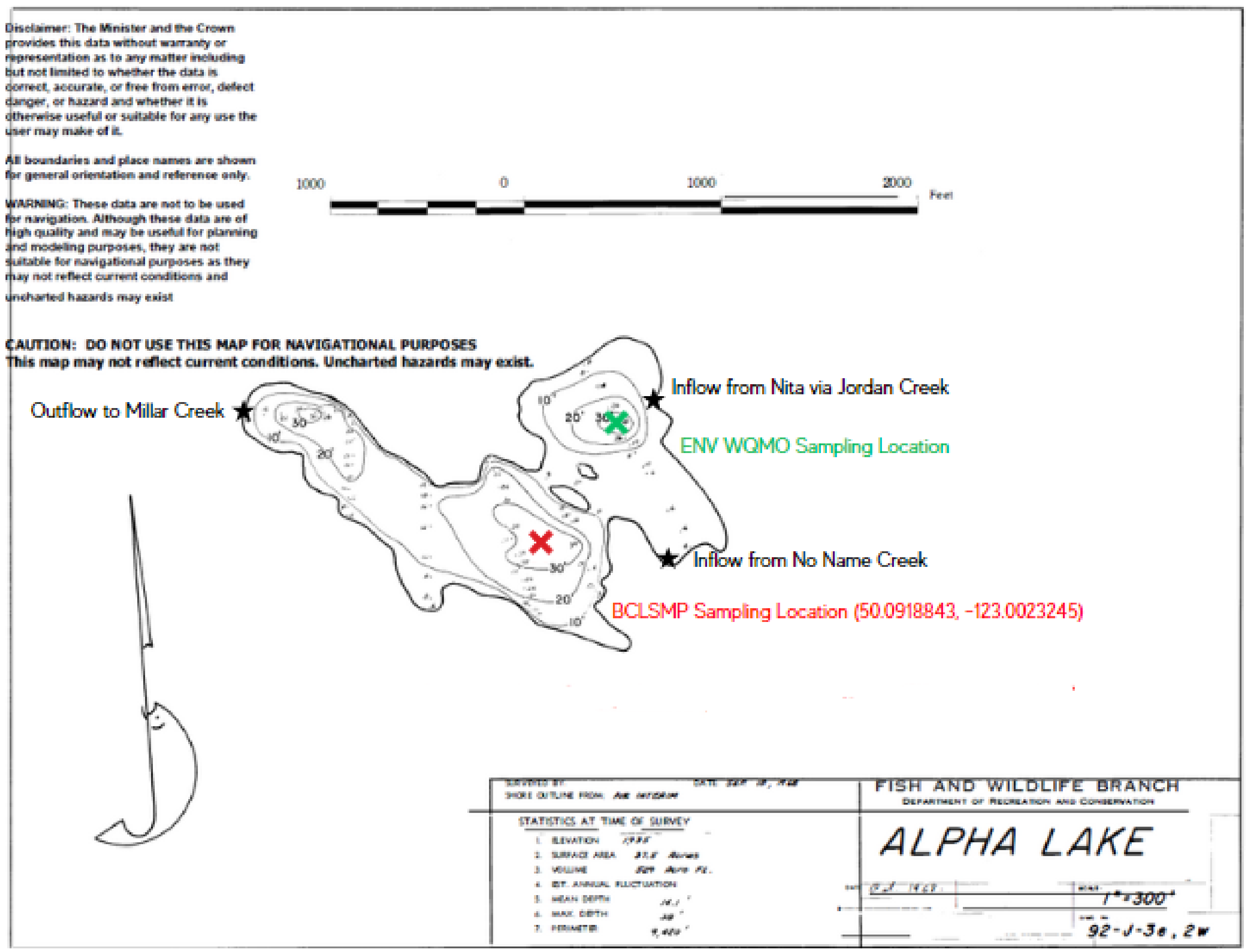
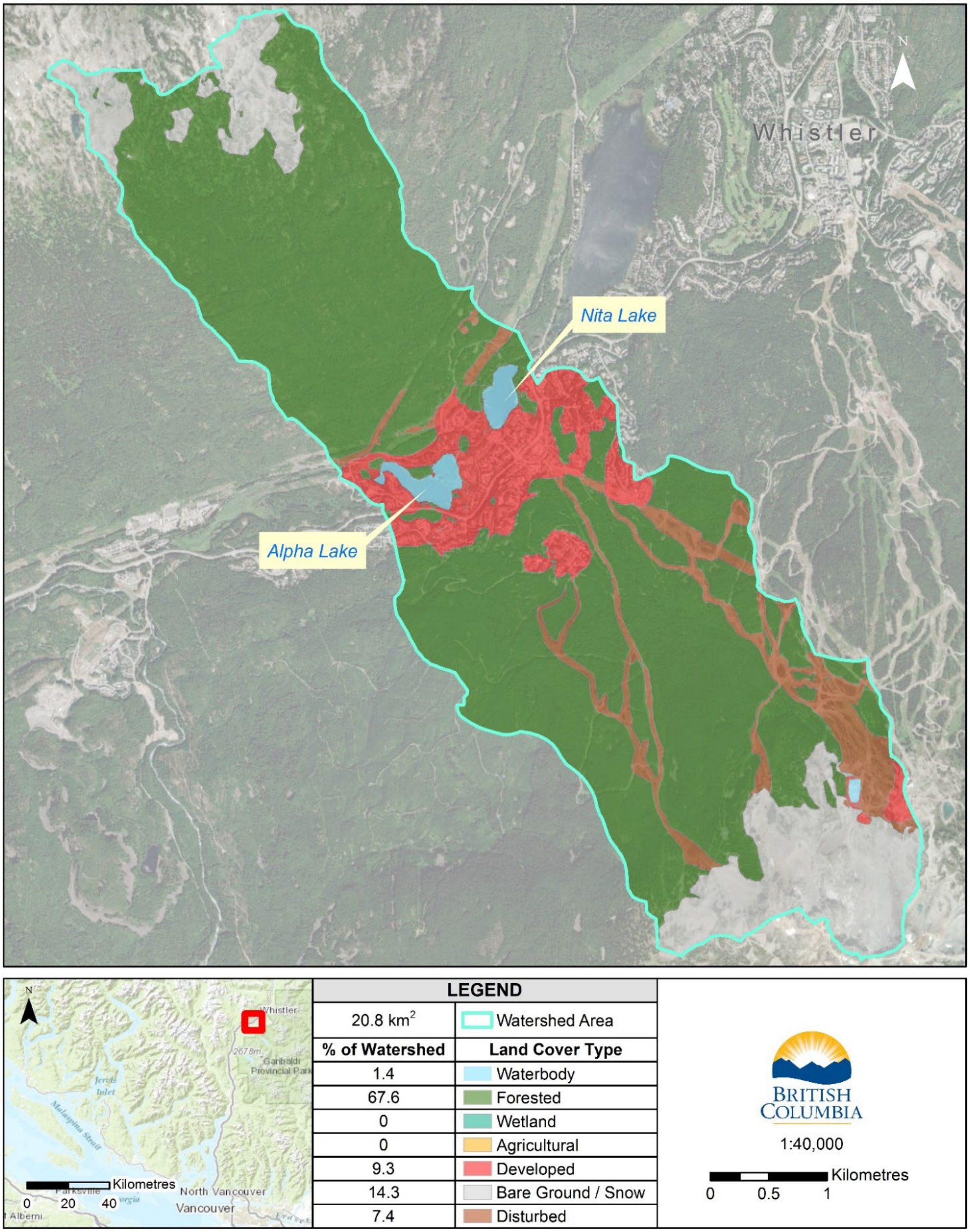


Figure 2. Bathymetric map of Alpha Lake, including BCLSMP Deep Station sampling site identified by the **red x**.

Monitoring Approach

This report focuses on summarizing Level 1 Study data collected by volunteers from the Whistler Lakes Conservation Foundation (WLCF) from 2021 to 2023. Volunteers also collected Level 1 BCLSMP Study data between 2005 and 2012, which is included in this report for longer-term temporal comparison. A Level 1 BCLSMP Study collects information from the lake location that best represents the entire lake, such as the centre or deepest point, and includes monitoring of surface temperature and water clarity (Secchi depth). In addition to surface temperature and clarity, in some years, volunteers were able to take temperature and dissolved oxygen profiles at depth intervals in Alpha Lake. Years that include profiles from this program are 2022, 2023, and some during the early years of monitoring from 2005-2008. Information on these parameters is recommended to be collected at least twelve times during the open water season, ideally for three consecutive years, to characterize the temporal variability typical of lake systems. This data provides valuable baseline and background information that helps in understanding what is happening in aquatic environments and observe long-term trends.

Level 1 BCLSMP water quality information was collected from Alpha Lake Deep Station between April and October during 33 sampling events in 2021, 16 sampling events in 2022, and 18 in 2023. Secchi depth and surface temperature were collected at each outing, and full temperature and dissolved oxygen profiles (i.e., measured at 1 m intervals throughout the water column) were also collected during all sampling events in 2022 and 2023.



Map By: B.C. Ministry of Environment and Climate Change Strategy Date Saved: 2024-02-29 3:45:31 PM Coordinate System: NAD 1983 UTM Zone 10N Datum: Transverse Mercator
Land Cover Type based on Sentinel-2 10m land cover time series of the world. Produced by Impact Observatory, Microsoft, and Esri. Orthophoto credit Esri basemaps

Figure 3. Alpha Lake watershed and associated land uses

Surface Temperature

Surface temperature readings serve as an important ecological indicator. By measuring surface temperature, we can record and compare readings from season to season and year to year. Surface temperature helps to determine many of the seasonal oxygen, phosphorus, and algal conditions. Volunteers collected surface temperature readings throughout the 2005-2012 and 2021-2023 monitoring seasons. It should be noted that the minimum data requirements of 12 readings spread over the sampling season were not met from 2005-2008. Additionally, the spread of measurements is not evenly distributed from spring through fall for most of the early years. The later years (2021-2023) have a much better spread of data from spring through fall, surpassing minimum data requirements each year. The variation in the spread of the data between historical and current monitoring significantly impacts the comparisons of yearly mean and minimum surface temperatures between historical and current data. In order to better assess if temperatures have changed significantly, **Figure 4** shows a July and August surface temperature summary from Alpha Lake, as well as the number of observations (n) in those months for each year. All years of monitoring had observations from July and August (except 2006, which did not have any readings in August), so comparing the minimum and means of these months will give us a better understanding of potentially significant changes.

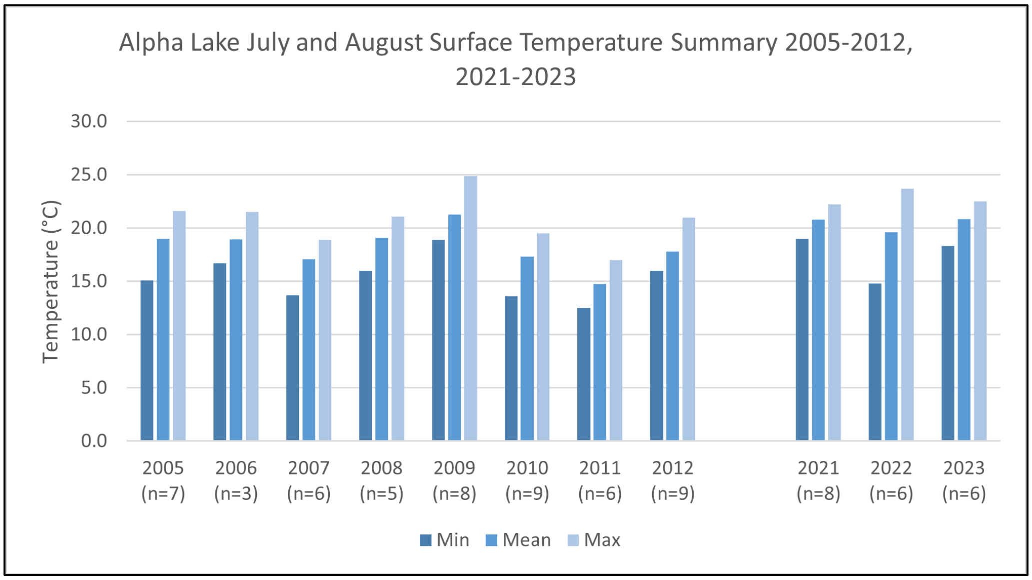


Figure 4 *Alpha Lake July and August Surface Temperature Summary 2005-2012, 2021-2023*

Figure 4 shows that surface temperature is variable from year to year, and there is no clear evidence showing a significant change between historical and current surface temperatures on Alpha Lake. The maximum surface temperature reading for July and August was 24.9°C (recorded on July 31, 2009). 2022 had the second highest July and August maximum at 23.7°C (recorded on July 30, 2022). The minimum surface temperature recorded in July and August was 12.5°C (recorded on July 19, 2011). The three years with the highest average surface temperatures in July and August are 2009 (average of 21.3 °C), and 2021 and 2023 both have the second highest average at 20.8°C. Further monitoring of temperature would be valuable going forward.

Temperature and Dissolved Oxygen

In addition to surface temperature, in some years volunteers were able to collect temperature and dissolved oxygen profiles on Alpha Lake. Temperature and dissolved oxygen (DO) strongly influence physical, chemical and biological processes in lakes. Annual temperature and oxygen patterns vary depending on local climate, lake shape, prevailing wind direction and lake depth (BCLSS, 2022). Water is most dense and therefore heavier at 4ºC and less dense (i.e., lighter) at both colder and warmer temperatures. During the summer, lakes usually experience a layering effect called stratification, with the warmer, less dense water sitting on top of the cooler and heavier water, separated by a thermocline. Stratification keeps bottom cool water isolated from top warmer water which traps nutrients released from bottom sediments until the layers mix in the fall. This mixing is also called lake overturn and can occur one to multiple times per year. During the mixing process, the bottom waters get recharged with oxygen, and nutrients are brought up to the surface. It should be noted that past reports have stated that Alpha Lake does not stratify at all over the summer and that water temperatures remain similar from the surface to the bottom (Epps & Phippen, 2016). Wetzel (2001) describes a thermocline as "the plane of maximum rate of decrease of temperature with respect to depth… usually accepted as a change of >1°C per meter". When using this definition of a thermocline, Alpha Lake does have a thermocline present at different times, so the lake stratifies, but to varying degrees each year.

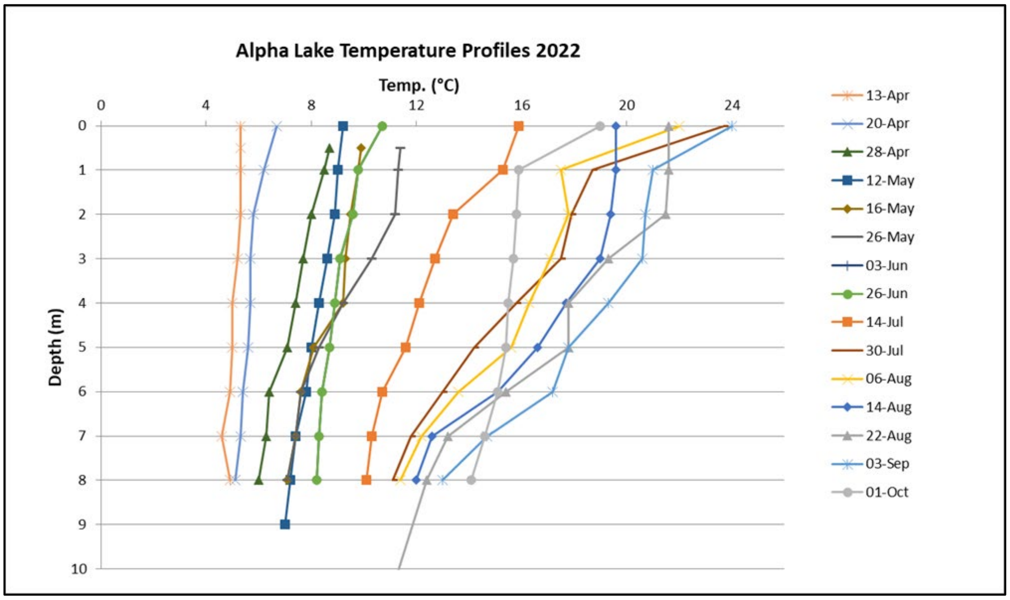


Figure 5 *Alpha Lake Temperature Profiles 2022*

Temperature Profiles

Years that include dissolved oxygen and temperature profiles are 2005-2008, 2022, and 2023. **Figure 5** and **Figure 6** show temperature profiles taken during the 2022 and 2023 monitoring periods, respectively. The first sampling event in 2023 (April 23) captured Alpha Lake in its mixed state, with water temperatures fairly uniform from top to bottom. As air temperatures warmed, the epilimnion warmed into the summer, stratifying the lake in 2023. The profiles taken in July depict a stratified lake with warm water in the epilimnion and cool water below the thermocline in the hypolimnion. The July 14 profile shows the most significant temperature range from the surface to the 9 m depth with an 11.8 °C difference from the surface to the bottom waters.

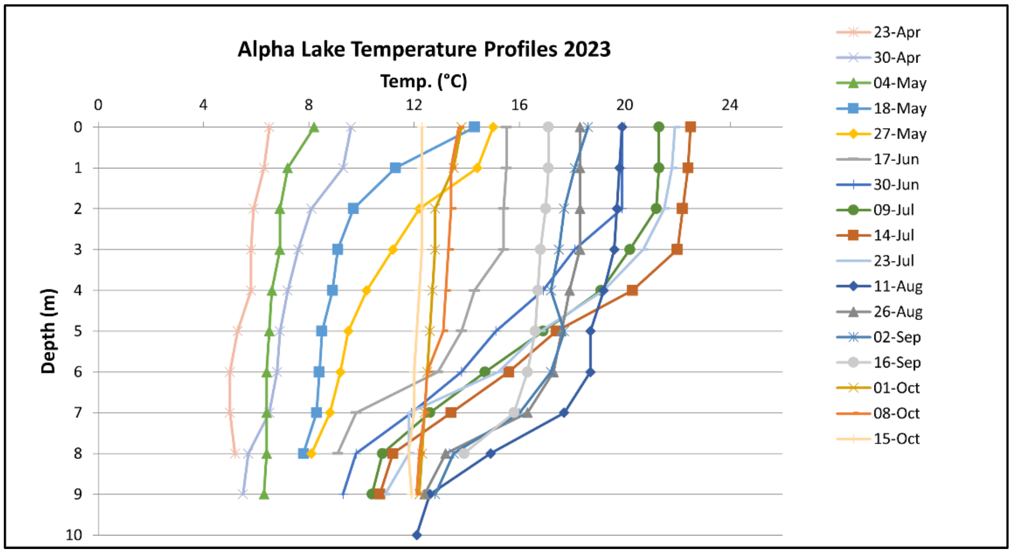


Figure 6 *Alpha Lake Temperature Profiles 2023*

Lakes of less than nine meters in depth may de-stratify for short periods during summer wind events which can influence nutrient cycling in such lakes (BCLSS, 2022). The 2022 profiles in Alpha show this occurring. The May 26 profile has a thermocline forming between 3-4 m; however, by the June 26th profile, the thermocline disappears. Then the July 14th profile indicates a thermocline was again starting to form, which can be seen between 1 and 2 meters. The most significant temperature difference from top to depth in 2022 was 12.6 °C on July 30.

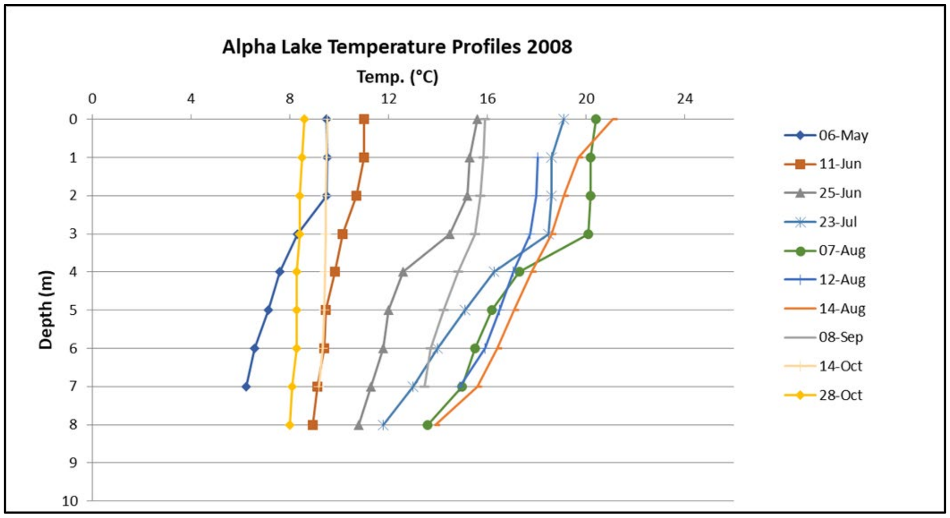


Figure 7 *Alpha Lake Temperature Profiles 2008*

From looking at profiles taken through the BCLSMP and in the Water Quality Assessment by Epps & Phippen (2016), Alpha likely varies in its degree of stratification each year. Some years, such as 2022, show that sometimes Alpha may experience significant temperature change from top to bottom waters (12.6 °C difference from top to bottom on July 30), while other years show a less significant change in temperature from top to bottom waters. For example, Epps & Phippen (2016) conducted profiles in 2009, when Alpha Lake experienced both its hottest surface temperature maximum and hottest surface temperature average for July and August recorded through the BCLSMP program. The graph displaying temperature profiles of Alpha from Epps & Phippen (2016) shows that the greatest temperature change captured from surface water to depth in 2009 was approximately 4.7 °C on July 16, with a thermocline appearing between 2-3m. It should be noted that this profile only went to a depth of 6m. However, it is still worth including this observation as later profiles during the most stratified time have a more significant change in temperature from surface to 6m depth. For example, 2022 experienced a 10.7 °C difference from surface waters to 6m depth on July 30.

It should also be noted that very few profiles were taken during the years of 2007-2009 through the Water Quality Assessment program, so the small change from top to bottom waters could be due to a lack of profiling of the lake during the hottest times in 2009. However, if only data taken through the BCLMSP program is considered, similar observations can be made. For example, from the profiles taken in 2008 (see **Figure 7**), the largest temperature difference from top to bottom measurements was 7.3 °C on July 23. It would be very useful to compare more years to determine if this observed larger temperature difference from top to bottom waters in current years is significant. Unfortunately, the 2005 and 2006 profiles provide little help with this analysis as both years only have profiles extending to 4m or a max depth of 5m. 2007 has some deeper profiles, and the most significant temperature gradient from surface to bottom captured in the 2007 profiles was on August 15, which was a 7.1 °C change from the surface to a depth of 8m.

To visually compare to the 2023 and 2022 profiles, 2008 was chosen as it has an early spring and fall reading, compared to most of the other historical years, which do not contain these readings. **Figure 7** shows that the lake did not stratify as strongly in 2008 compared to 2022 or 2023. The largest change from surface to bottom waters captured by monitoring events was an 11.8 °C difference from surface to bottom waters in 2023 and a 12.6 °C gradient in 2022. The largest difference in 2008 was a 7.3 °C change from surface to bottom waters on July 23. It should be noted that measurements for 2008 extended a meter shallower than the measurements in 2023.

When comparing profiles from 2007, 2008 (BCLSMP) and 2009 (WQMO), to 2022 and 2023 profiles, it appears that Alpha stratifies to different degrees year to year, however, in general, it may be starting to support a larger temperature gradient from top to bottom waters than what was captured historically. For years, when this stronger stratification happens, there is a greater barrier to mixing that will be more difficult to overcome by wind or temperature changes, normally leading to intermixing events. If a more significant summer temperature gradient from top to bottom waters is indeed becoming more pronounced in Alpha Lake, it can have substantial impacts to dissolved oxygen levels and nutrient cycling. Many of the early year's profiles do not span the full water column or were conducted less frequently, so at this time, firm conclusions are not possible, however, recommendations can be made to help guide monitoring in future years.

The 2021-2023 data represents the entire water column and more frequent and temporally spaced data from spring to fall will allow more complete long-term data comparisons moving forward. For subsequent years of data collection, it is recommended that profiles continue to be conducted as soon as possible from ice off and continue at least biweekly until complete turnover is caught in the fall. This is important to determine if Alpha Lake's stratification pattern is changing over time. One of the impacts of climate change on lakes in BC is that stratification may occur for longer periods of time, which can have extensive implications on dissolved oxygen levels, nutrient cycling, and habitat availability for salmonid species (Ashley, 2024). Lakes will vary in how they respond to a warmer climate, which supports the need to collect as much data as possible on Alpha Lake as well as other BC lakes.

Dissolved Oxygen Profiles

Dissolved oxygen (DO) is essential to aquatic life in lakes. Oxygen from the atmosphere dissolves and mixes into the water's surface and is also released from plants and algae during photosynthesis. Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the health of a lake by studying oxygen patterns and levels.

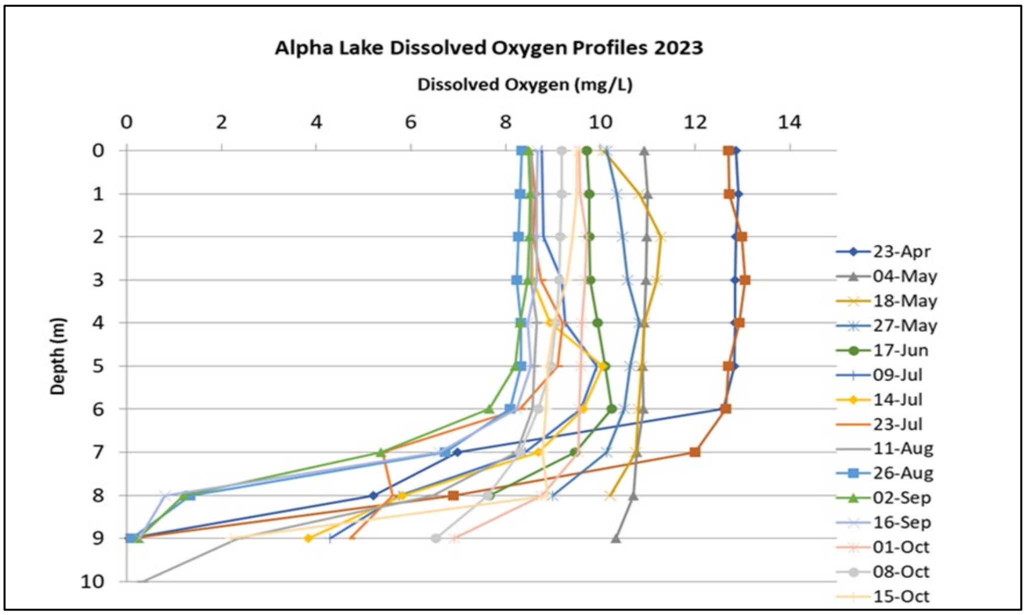


Figure 8 *Alpha Lake 2023 Dissolved Oxygen Profiles*

Generally, lakes that are lower in nutrients and algae production will have sufficient DO to support life at all depths throughout the year. As lakes become more nutrient and algae rich there is increased plant and animal respiration and decay, resulting in more oxygen consumption. This is especially true near the bottom of the lake where dead organisms can accumulate, and oxygen is depleted more rapidly. Stratified lakes with low oxygen concentrations in the isolated bottom layer can impact the behaviours and locations of fish residing within the lake. Sensitive fish species, such as many salmonids, can become stressed when oxygen concentrations fall below 4 mg/L (Truelson, 1997) and begin to move up the water column to areas with higher DO concentrations. Fish kills can occur when decomposing or respiring plants and algae use up the oxygen supply. In summer, this can happen on calm nights after an algal bloom, but most fish kills occur during late winter or at initial spring mixing, as oxygen-depleted bottom water is mixed into the rest of the water column.

Because of the extensive impacts dissolved oxygen changes can have on a lake, it is important to compare historical and current dissolved oxygen profiles to determine if dissolved oxygen levels have significantly changed within the water column over time. Apart from some profiles in 2007 and most in 2008, the majority of the historic BCLSMP profiles on Alpha stopped by 5m depth, which makes comparing hypolimnetic oxygen levels difficult because the 2023 profiles (**See**

Figure 8) show that any oxygen depletion is typically evident below 6m depth. As shown in **Figure 8,** dissolved oxygen levels near the bottom were being depleted from late August into September 2023. It is worth noting that field notes from these dates may point to the probe being on or in the bottom sediments at the 9m mark on different occasions, and the WLCF volunteer has confirmed that the probe was at the bottom at 9m. Readings below this are likely in the bottom interstitial sediment/water (McFarlane, 2024) and not valid. Below 7 meters during these sampling events (Aug 2nd and 26th, Sept 2nd and 16th) in 2023, the oxygen levels were below the safe guideline for salmonid species (less than 5 mg/L) (B.C. Ministry of Environment, 1997). This drop below the guideline is only evident once from the 2008 profiles, on July 23, with the 8 m depth reaching the lowest dissolved oxygen level recorded for the year at 4.91 mg/L; however, many of the profiles only reached 7m in these early years. This is similar to the profiles included in the Epps & Phippen (2016) report, which typically only extended down to 7m. No measurements below 5 mg/L are evident in any of the profiles taken by ENV for the WQMO program between 2007-2009 (Epps & Phippen, 2016). However, the profiling through this program was limited and occurred less frequently than BCLSMP profiling.

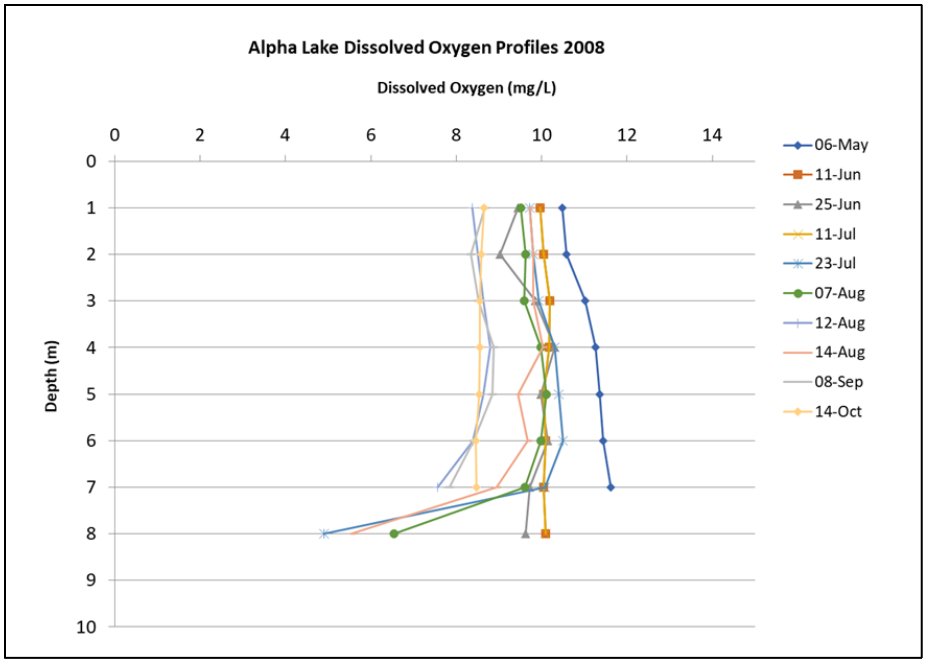


Figure 9 *Alpha Lake 2008 dissolved oxygen profiles*

It is recognized that oxygen depletion in water near the bottom of lakes is expected in most lakes of moderate to high biological productivity. However, dissolved oxygen depletion near the bottom of Alpha Lake should continue to be monitored as low dissolved oxygen can have implications for salmonid species and influence chemical changes in the sediment. Under aerobic (oxygenated) conditions, much of the phosphorus in a lake is bound to iron, manganese and/or calcium contained in lake bottom sediments. When bottom waters become anoxic, chemical changes occur in the sediments that result in phosphorus being released into the water column. When the lake begins to turn over, the phosphorus is mixed into the photic zone where algae and plants can utilize it, sometimes resulting in blooms. This phenomenon is known as internal loading. Iron, manganese, and hydrogen sulphide (H_2S) can also be released into the bottom water during these anoxic periods (BCLSS, 2022).

Many fish species, especially salmonids, show signs of stress at temperatures greater than 18°C and DO concentrations less than 4 mg/L (Truelson, 1997). Temperature and DO results show that despite the low oxygen levels below 6m depth and warm surface water conditions in the summer of 2023, much of the water column in the Alpha Lake deep station remained suitable habitat for fish. On occasion in 2023, habitat within the water column that was less than 18°C in temperature but contained greater than 4 mg/L of DO was as small as a 2m layer (August 11, 2023, between 6-8 m). As the climate warms in the future, there is a chance this layer of comfortable conditions for salmonids may decrease, so it will be important to monitor moving forward.

Water Clarity

Water clarity is an indicator of algae, suspended sediments, and other particles in the water. The clarity of the water can be evaluated by using a Secchi disc, a 20 cm diameter black and white disc that measures the depth of light penetration. Natural variations and trends in Secchi depth and temperature occur not only between years but also throughout one season. In general, as temperatures increase during the summer months, Secchi depth typically decreases. This is due to algal growth patterns; as the temperature of the lake increases, so do some species of algae. Due to the increase in algae, the water clarity can decrease. However, there can be other influences on Secchi readings, such as suspended solids from turbid inflowing streams.

Water clarity was measured at the Alpha Lake Deep Station from 2005-2012 and from 2021-2023. The graphs in **Figure 10** show the Secchi readings collected by volunteers from 2021-2023. The minimum data requirement of 12 readings over the sampling season was exceeded each year from 2021-2023, and the spread of measurements was fairly evenly distributed from spring through fall. It should be noted that despite volunteers following correct protocol when taking Secchi measurements in 2022, there were significant differences (~1.5 m) in readings collected by a BCLSS staff member and volunteer during a routine check-in. The staff and volunteer repeated the measurements and still received different Secchi depths. It was hypothesized that the differences may be due to eyesight. It should be noted that this volunteer did not lead the sampling in 2023, so if Secchi depth increased in 2023 compared to 2022 any conclusions drawn from the changes will need to first consider the difference in volunteers between years.

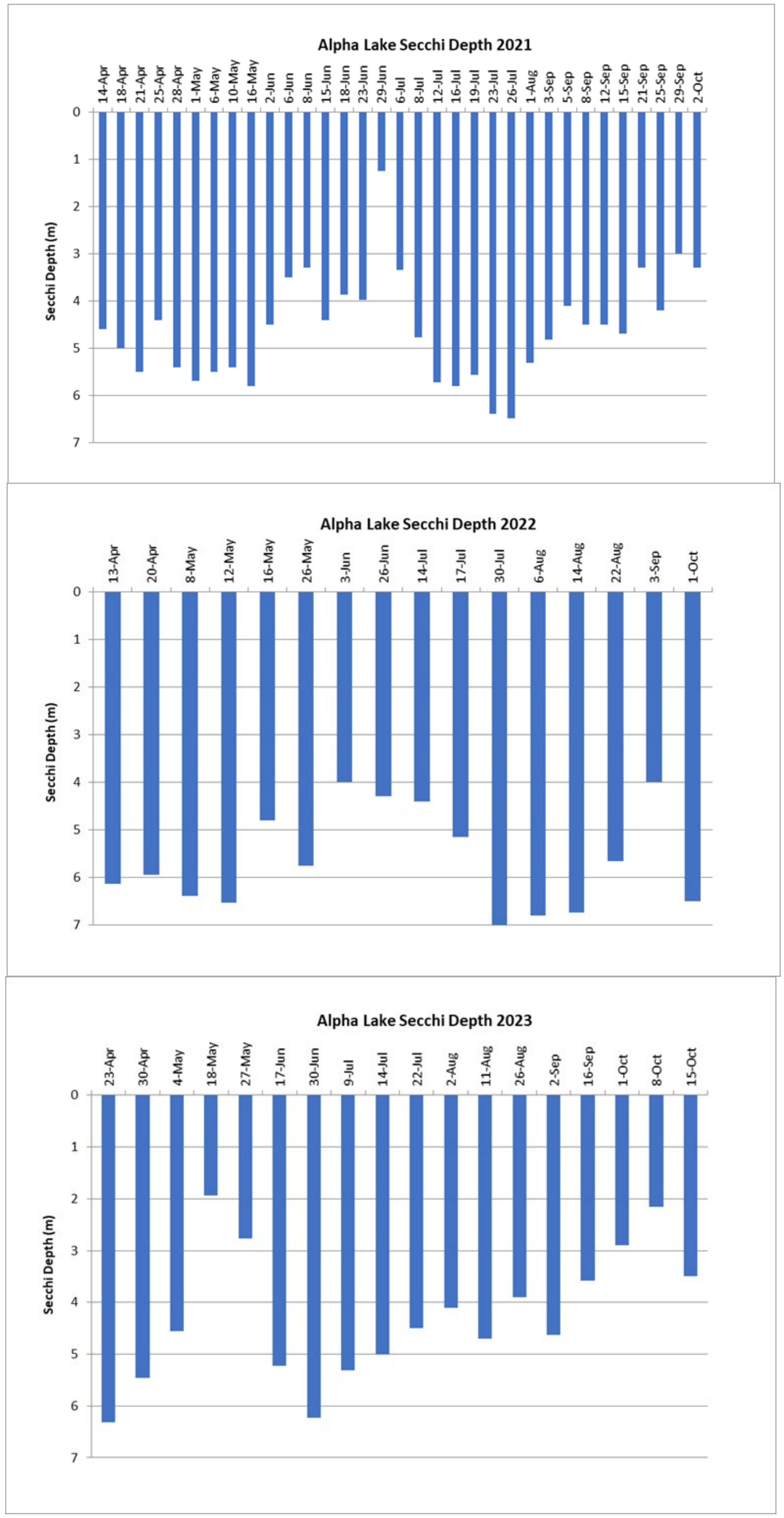


Figure 10 *Secchi readings in Alpha Lake 2021-2023*

June has some of the shallowest Secchi readings in Alpha Lake for 2021 and 2022. June 29, 2021, had the lowest Secchi reading recorded on Alpha Lake out of all of the years of data collection (1.25 m). The reading did accompany the warmest air temperature recorded for the year (30 ºC). Typically, as mentioned above, warm temperatures coupled with low Secchi depths may indicate algae growth. However, according to volunteers, algae has not been a problem on Alpha Lake, though it is worth noting that there is significant plant life in the shallower sections of the lake (Doyle, 2024)[1]. This low Secchi reading is instead thought to be linked to turbid inflows into Alpha Lake. Volunteers have noted that turbid waters occasionally flow into the lake, and there are noticeable changes in water level after storms or melt temperatures during the summer, likely associated with large amounts of water coming into the lake from Jordan Creek and/or No Name creek (Collins, 2024). Previous reports have also discussed that the hydrology of the area is mainly snowmelt-driven, with water levels starting to rise in May with peaks in mid-July, as well as occasional fall peaks driven by rain events (Epps & Phippen, 2016). This pattern likely has a significant impact on Secchi readings, as low readings between May and July may be linked to increasing turbidity due to snowmelt runoff. This statement corresponds to the low readings in June and July in 2021 and 2022. However, the pattern of low June/July Secchi readings is not apparent in 2023. The low readings in early 2023 are not thought to be linked to an algal bloom but likely linked to earlier-than-usual peak snowmelt due to warm temperatures. Another factor that may be impacting Alpha Lake Secchi readings is that the shallow depth of the lake may make it susceptible to re-suspension of bottom sediments (BCLSS, 2007).

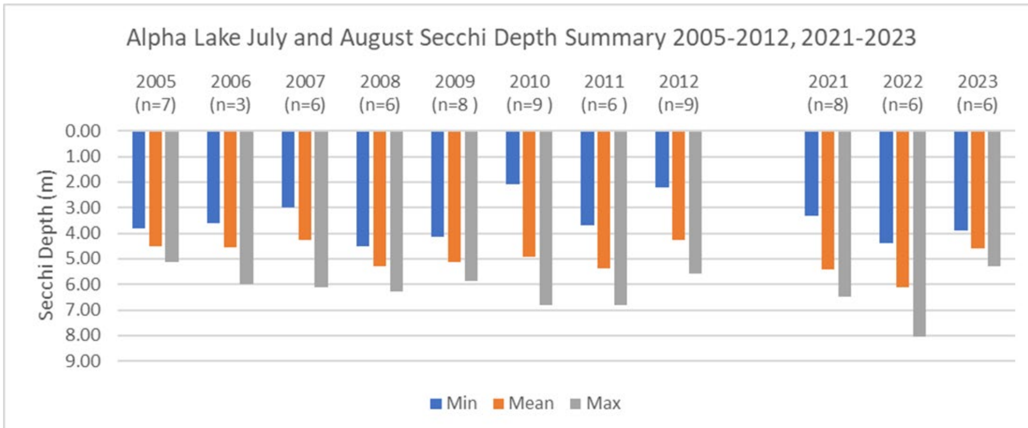


Figure 11 *Alpha Lake Secchi Depth Summary for July and August 2005-2012, and 2021-2023*

To assess whether the clarity of Alpha has changed significantly over time, we can compare the average, maximum, and minimum Secchi readings from each year. Since the timeframes of sampling differed for historic versus current years, with 2021-2023 having a longer temporal spread of readings from spring through fall, as in the surface temperature section, overall summary statistics cannot be compared. Instead, July and August Secchi summary statistics were chosen for comparison between years in **Figure 11**. Though all years had readings in July and August (except 2006, which did not have any readings in August), it is extremely important to note that early years of data collection often did not follow the Secchi reading protocol (readings should be collected between 10:00 a.m. -2:00 p.m.), which could have affected the readings due the angle of the sun and ability of light to penetrate through the water column.

The maximum reading in July/August was 8.05 m on July 30, 2022, and the minimum was 2.10 m on July 14, 2010. The graph does not strongly support any significant trend in clarity between the historical or current BCLSMP data. Additionally, considering the limited number of Secchi readings in July and August, the historic Secchi observation window often not falling between 10:00 a.m. and 2:00 p.m. (or has no time recorded at all), and the 2022 quality control check in showing a large variation in Secchi depth depending on the person taking the measurement, we cannot make a real conclusion on whether the clarity of Alpha has changed over time.

It is recommended that further monitoring be conducted with more comprehensive field comments and observations of the condition of the inflowing streams during the time of sampling. Ideally, this would involve observations and/or photos of the inflowing streams for turbid conditions at the time of the Secchi reading. Comments like these will greatly help in the future when analyzing Secchi readings in Alpha Lake. Additionally, considering the impact of snowmelt and runoff events proven to impact Whistler Lake waterbodies (Bull, 2009), chlorophyll-*a* monitoring should be considered to instead provide information and tracking of any long-term changes to algal growth in Alpha Lake.

[1] It has been noted by Collins (2024) that in a survey by Beak Consultants in 1978, the pondweed Potemogeten sp. was not found, while in 2023 Collins has found that *Potemogeten amplifolius* is now common in the middle depths.

Trophic Status

Trophic status describes the level of biological productivity within a water body and is measured by using Secchi depth, chlorophyll-*a*, and total phosphorus concentrations (Nordin, 1985). Low-productivity lakes are called *oligotrophic* and tend to have clear water and sufficient oxygen for aquatic life throughout the year. Lakes with moderate productivity are called *mesotrophic*. *Eutrophic* lakes have high productivity and often have high densities of aquatic plants and/or algae. Algal blooms may occur in these lakes frequently, reducing recreational opportunities and potentially impacting aquatic habitat.

The results show that Alpha Lake ranges from low to low-moderate productivity depending on the time period and the trophic indicator (**Table 1**). Both the historic July and August water clarity (i.e., Secchi depth), as well as the more recent data collected through the BCLSMP suggest the lake is mesotrophic. However, as noted in the water clarity section, the clarity of Alpha Lake is likely impacted by snowmelt and runoff, as well as the resuspension of bottom sediments. Therefore, Secchi depth is less useful in providing signs of trophic status. The average chlorophyll-*a* as well as the total phosphorus concentrations monitored to advise the draft Water Quality Assessment program document by Epps & Phippen (2016), between 2008-2010, places the trophic status of Alpha Lake within the oligotrophic category. Alpha Lake is likely oligotrophic, however further monitoring that includes chlorophyll-*a* is warranted.

Table 1. Alpha Lake trophic indicator results (as per Nordin, 1985).

Parameters	**Trophic Categories**			**Alpha Lake**		
	Oligotrophic	Mesotrophic	Eutrophic	BCLSMP L1 (2005-2012)	ENV WQA (2008-2010 for P, 2007-2009 for Chla)	BCLSMP L1 (2021-2023)
Chlorophyll-*a* (µg/L)[3]	0 - 2	2 - 7	>7	-	<1.2	-
Secchi Depth (m)[1]	>6.0	3.0 - 6.0	<3.0	4.79	-	5.38
Total Phosphorus (µg/L)[2]	1 - 10	10 - 30	>30	-	4	-

[1] Average of all years' July and August average Secchi depth, [2] Overall annual mean during spring conditions, [3] Overall annual average over 3 years based on 2-3 samples per year.

Flushing Rate

Flushing rate, also referred to as Water Exchange Rate, is the rate of water replacement in a lake. It's unit of measure is times/year. Lakes with high flushing rates are less sensitive to the impact of human-caused nutrients from land use or other development (BCLSS, 2022). The flushing rate of Alpha Lake has been calculated by Collins (2024) to be approximately 25.5 times per year, and this is considered to be very high. Collins points out that "such high flushing rates mean that algal nutrients arriving from the watersheds annually are not all there at once, and the algal populations that that grow on them will themselves experience rapid losses downstream."

Summary

Alpha Lake is a small, shallow lake located in a developed watershed. The lake is extremely popular with recreational users for boating (electric motors only), paddling, swimming, and fishing. The lake has been changed quite significantly from its original state due to human development leading to three areas of the lake being filled. The lake was monitored by the Whistler Lake Conservation Foundation under the BCLSMP Level 1 program over a three-year period between 2021 and 2023. In 2022 and 2023, the volunteers were able to obtain dissolved oxygen (DO) and temperature profiles on Alpha Lake, which contradicted previous information that Alpha Lake does not stratify at all throughout the summer. This that the lake does stratify to varying degrees each year and is likely prone to intermixing events due to its shallow nature. Temperature and DO results from 2023 show that because of deep water low oxygen conditions during the late stratified period and warm surface water conditions during the summer, suitable habitat for fish that is less than 18ºC in temperature and greater than 4 mg/L of DO may be limited at Alpha Lake Deep Station. On one occasion in 2023 (August 11), the suitable habitat within these levels was less than 2m within the water column. However, most of the year supports larger ranges of suitable habitat exist within the water column.

Algal productivity and phosphorus concentrations taken from different years and through a different sampling program suggest that Alpha Lake is a low-productivity system (oligotrophic). Secchi depths indicated that Alpha Lake may be moderately productive (mesotrophic). However, water clarity should not be relied on as the sole indicator of productivity for Alpha Lake due to snowmelt and stormwater runoff likely impacting the clarity of the lake, as well as the potential resuspension of bottom sediments. Comparing profiles taken through the BCLSMP program and the Water Quality Objectives program for 2008, 2009, 2022, and 2023 suggests that Alpha Lake may be supporting a larger temperature gradient from top to bottom waters than it did historically, however, this cannot be confirmed due to limitations on historical data and a limited number of years for comparison. However, stratification patterns and temperature gradients in the lake should be monitored going forward. Years when the lake surface is warmer for longer (i.e., earlier in the spring and/or later in the fall) can result in longer and stronger lake stratification, greater oxygen depletion at the bottom of the water column and more nutrients released from lake sediments.

Alpha Lake has a high flushing rate and can be considered less sensitive to the impact of human-caused nutrients from land uses or other development.

Going Forward

The land use pressures within the Alpha Lake watershed are relatively high due to development along the lake and its main tributaries, as well as significant human alteration of the lake from its original state. An analysis by Collins (2024) identifies considerable residential development on the lake and associated impacts on the lake shoreline. Collins (2024) points out that the stormwater washing off these lots will all end up in Alpha Lake and that there are quite a number of stormwater conduits from streets and lots in Creekside near the southeastern margin of the lake that enter the east edge of the eastern basin.

With a new development going in along the West side of Nita Lake (upstream from Alpha), development pressures will continue to increase. Studies have shown that stormwater runoff can impact Whistler Creeks (Bull, 2009). However, the Resort Municipality of Whistler plans to mitigate the impacts of increasing development pressures by requiring all new developments to take stormwater impacts into account as part of the development permit procedures (Burhenne, 2024). Adequate shoreline protections, including healthy riparian buffer zones, can also act to mitigate development impacts on water quality and fish habitat (Dosskey et al., 2010).

There is strong evidence that climate change is exacerbating existing issues in lakes and creating issues where issues did not previously exist, whether expected or unexpected. This will make the management of BC's water resources more challenging. One climate change impact already observed in many northern hemisphere lakes is reduced oxygen concentrations and earlier onset and longer periods of stratification, which will make internal nutrient loading more problematic (Woolway et al., 2020). If there is volunteer interest and capacity, continued monitoring should be done through an Enhanced Level 1 BCLSMP program: Secchi depth, dissolved oxygen (DO) and temperature profiles at Alpha Lake Deep Station from spring to fall overturn is recommended. The WLCF has purchased their own temperature and DO meter and water column profiling for these two parameters on a regular basis between spring and fall mixed periods will provide extremely valuable information. These data are important for long-term lake condition records and will provide early warning signs of deterioration in water quality. In addition, specific conductance profiling would also be valuable as it can help provide information on road salt inputs into the lake.

Considering the clarity of Alpha Lake is likely linked to sedimentation and increased turbidity levels during rainfall and snowmelt events as well as when bottom sediments are resuspended, designing a chlorophyll-*a* sampling program to compliment the program recommended above would provide a better indication of algal growth and trophic status in Alpha Lake. This should be accompanied by observations of sediment entering via the tributary streams and in the lake itself during monitoring events.

These data are important for long-term lake condition records and will provide early warning signs of deterioration in water quality. It is also recommended that monitoring include ice-on and off dates which can be submitted online through BC Lake Ice Reporting Tool (https://arcg.is/qy1e5). This data is important for tracking climate change impacts on BC lakes.

Tips for Keeping Alpha Lake Healthy

- Protecting and enhancing natural shoreline vegetation will likely be important for mitigating impacts from increased development in the Alpha Lake watershed. Tree branches and riparian zone vegetation should remain intact whenever possible because high-quality riparian areas are key for supporting good water quality and healthy fish populations. “The vegetation in riparian areas directly influences and provides important fish habitat, it builds and stabilizes stream banks and channels, provides cool water through shade, and provides shelter for fish. The leaves and insects that fall into the water are also a source of food for fish” (B.C. Government, n.d).

- Continue to monitor road salt usage to avoid applying more salt than needed. Road salts are known to end up in waterways and can impact water quality (ECCC, 2018).

- Residents report that snow is often piled up along the lakeshore or dumped into creeks/the lake itself. Dumping snow in this manner can negatively impact water quality because snow that is removed from streets and walkways can include salt, sand, organics, metals and debris which are contaminants of concern (Warrington & Phelan 1998). However, the Resort Municipality of Whistler maintains this is not a regular practice (Burhenne, 2024).

Other Tips for Keeping Alpha Lake Healthy:

See link under Monitoring Resources on: www.gov.bc.ca/lakestewardshipmonitoring
BCLSS’s LakeKeepers Manual: https://www.bclss.org/programs#lake-keepers-manual

Who to Contact for More Information

The Ministry of Environment and Parks	**The BC Lake Stewardship Society**
3rd Floor, 1011-4th Ave Prince George, BC V2L 3H9 Email: volunteerlakes@gov.bc.ca Website: www.gov.bc.ca/lakestewardshipmonitoring	Box 110, 5505 Jacobson Road, Big Lake Ranch, BC, V0L 1G0 Email: info@bclss.org Website: www.bclss.org

Acknowledgements

Volunteer Monitoring by: Nick Collins, Andrew McFarlane, Megan Pallet and Al Peruzzo of the Whistler Lakes Conservation Foundation
Data Compilation by: Amy Baxter (BCLSS)
Lake Report Production by: Amy Baxter (BCLSS)
Report Review: Norm Zirnhelt, Rick Nordin (BCLSS); Nick Collins, Andrew McFarlane, John Doyle, & Ross Clark (Whistler Lakes Conservation Foundation); and Kirsten McNeill (ENV)
Land Use Map by: Kim Klaczek (ENV)

References

Ashley, K. 2024. Predicted impacts of climate change on BC Lakes. BCLSS. Retrieved February 11, 2024, from https://www.bclss.org/environmental-issues/predicted-impacts-of-climate-change-on-bc-lakes

BC Lake Stewardship Society (BCLSS). 2007. BC Lake Stewardship and Monitoring Program. Alpha Lake 2005 – 2007. https://www.bclss.org//wp-content/uploads/2017/05/alpha_lake_05-07_final.pdf

BC Lake Stewardship Society (BCLSS) 2022. LakeKeepers Manual. A Guide to Lake Stewardship and Ecology in British Columbia. Retrieved January 5, 2024, from https://www.bclss.org/programs#lake-keepers-manual

BC. Government. N.d. Introduction to the Riparian Areas Regulation. Gov.bc.ca. Retrieved February 10, 2024, from https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/introduction_to_rar.pdf

B.C. Ministry of Environment. 1997. Ambient Water Quality Criteria for Dissolved Oxygen. [Online] 1997. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/dissolvedoxygen-or.pdf

Bull, Jennifer. 2009. Assessments of Stormwater Quality and Snowmelt Runoff in Whistler Creeks 2007-2008. BC Ministry of Environment, Surrey, BC

Burhenne, L. 2024. Personal communication. Manager Of Climate & Environment for the Resort Municipality of Whistler. Email February 8, 2024.

Clark, R. 2024. Personal communication – Alpha Lake Questions for Volunteer Monitors sent by email. Seasonal or permanent resident of Whistler 1976. March 10, 2024.

Collins, N. 2024. Alpha Lake Review Comments. Limnologist. Associate Professor of Biology Emeritus. University of Toronto, Mississauga, Ontario.

Collins, N. 2024. Personal communication – Alpha Lake Questions for Volunteer and Residents sent by email. BCLSMP Lead Alpha Lake Monitoring Volunteer. March 10, 2024.

Dosskey, M. G., Vidon, P., Gurwick, N. P., Allan, C. J., Duval, T. P., & Lowrance, R. (2010). The role of riparian vegetation in protecting and improving chemical water quality in streams. JAWRA Journal of the American Water Resources Association, 46(2), 261–277. https://doi.org/10.1111/j.1752-1688.2010.00419.x

Doyle, J. 2024. Personal communication – Alpha Lake Questions for Volunteer and Residents sent by email. Full and Part Time Resident of Whistler Lake since 2009. March 10, 2024.

Environment and Climate Change (ECCC). (2018, August 14). Government of Canada. Canada.ca. Retrieved January 27, 2024, from https://www.canada.ca/en/environment-climate-change/services/pollutants/road-salts/frequently-asked-questions.html

Epps, D., and Phippen, B. 2016. Water Quality Assessment and Objectives for Alta Lake, Alpha Lake, Lost Lake And Nita Lake: Resort Municipality of Whistler, B.C. Unpublished manuscript, Environmental Protection Division, Environmental Sustainability Division, Ministry Of Environment, Government of British Columbia.

Freshwater Fisheries Society of BC (FFSBC). 2023. Fish stocking reports - Alpha Lake. Freshwater Fisheries Society of BC. https://www.gofishbc.com/stocked-fish/?waterbody=ALPHA&reportType=lake

McFarlane, A. 2024. Alpha Lake Review Comments. Volunteer Monitor. Whistler Lakes Conservation Foundation.

Nordin, R. 1985. Water Quality Criteria for Nutrients and Algae. Water quality Unit, Resource Quality Unit, Resource Quality Section. Ministry of Environment, Lands and Parks. Victoria, BC.

Rebellato, B. 2005. As cited in BCLSS, 2007. Personal communication - written summary of four Whistler lakes sent by email. Fish and Wildlife Technician. Resort Municipality of Whistler. August 31, 2005.

RMOW. 2024. Water Quality. Resort Municipality of Whistler. https://www.whistler.ca/services/environmental-stewardship/water-quality

Truelson, R.L. 1997. Water quality criteria for dissolved oxygen. Prepared for British Columbia's Ministry of Environment, Lands and Parks, Water Management Branch, Victoria

Warrington, P., & Phelan, C. 1998. Roadsalt and Winter Maintenance for British Columbia. Government of British Columbia. https://a100.gov.bc.ca/pub/acat/documents/r15858/RoadsaltandMaintenance_1233164349911_0f308e8c5a1c21e81436e2043ecd8879cca7076bd3c6e889d6245abb2154d899.pdf

Wetzel, R. G. (2001). Limnology: Lake and river ecosystems. Elsevier Science.

Woolway, R.I., M. Kraemer, J.D. Lenters, C. J. Merchant, C. M. O'Reilly and S. Sharma. 2020. Global lake responses to climate change. Nature Reviews Earth & Environment volume 1, p388–403.